Morphological productivity and family size:
evidence from French compound nouns garde-x and N-de-N

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0. Abstract

Recent work in derivational morphology have shown a new interest for the concept of morphological productivity and its various measuring tools, both quantitative (Baayen, 1992; 1993; Baayen & Lieber, 1991; Baayen & Renouf, 1996) and qualitative (Bauer, 2001; Dal, 2003). However, the productivity of compound words has been very little explored, especially in French, except for the work of Krott, Schreider & Baayen (1999). Recent studies have proposed a new approach to morphological productivity in terms of family size (De Jong, Schreuder & Baayen, 2000; del Prado M., Bertram, et al., 2004). This paper explores a possible correlation between morphological productivity and family size and is based on the results of a quantitative study of French compounds garde-x and N-de-N from 1606-1920. The result of study indicates that there is a negative correlation between the productivity and family size of compounds garde-x. The growth of the morphological family increases the level of productivity of these compounds. In case on N-de-N compounds, the study demonstrated mixed results: the correlation was negative for first and second analysed periods, but positive for the third and fourth period.

0. Résumé

Des travaux récents dans la morphologie dérivationnelle ont démontré un nouvel intérêt pour le concept de la productivité morphologique et pour ses outils de mesure en utilisant une méthode quantitative (Baayen, 1992; 1993; Baayen & Lieber, 1991; Baayen & Renouf, 1996) et qualitative (Bauer, 2001; Dal, 2003). Cependant, la productivité des mots composés a été très peu explorée, particulièrement en français, à part le travail de Krott, Schreider et Baayen (1999). Récemment, une nouvelle approche vers la mesure de la productivité morphologique en terme de la taille de la famille morphologique a été proposée (de Jong, Schreuder & Baayen, 2000; del Prado et al., 2004). Ce papier étudie une corrélation possible entre la productivité morphologique et la taille de la famille morphologique des composés français garde-x et N-de-N des 1606 à 1920. Le résultat de la recherche indique qu'il existe une corrélation négative entre la productivité et la taille catégorielle de la famille morphologique des composés garde-x. La croissance de la famille morphologique augmente le niveau de la productivité de ce type de composés. En ce qui concerne les composés N-de-N, la recherche a montré des résultats mixtes : la corrélation était négative pour la

première et deuxième période étudiée, mais elle était positive pendant la troisième et quatrième période.

Keywords: Morphology, morphological productivity, morphological family size, diachrony, linguistic corpus, French compounds

Mots-clefs : Morphologie, la productivité morphologique, la taille de la famille morphologique, la diachronie, le corpus linguistique, les composés français

1. Introduction

The notion of productivity can be approached from both a qualitative or quantitative angles. From qualitative standpoint, the productivity is defined as the capacity of morphological rules to form new lexemes in a non intentional manner (Dal 2003: 5) using the available morphological process (Bauer 2001:49). From the quantitative standpoint, several methods based on the linguistic corpora were proposed to measure different aspects of productivity (Baayen & Lieber, 1991; Baayen, 1992; 1993; Baayen & Renouf, 1996). The productivity of French compound words is very little explored: except for the work of Krott, Schreider & Baayen (1999) and Fernández-Domínguez (2007, 2008) the studies on the measure of productivity have not been applied to compounds.

Currently, the often used calculations of morphological productivity are presented by Baayen (1991, 1996, 1999). Baayen proposes two measures of morphological productivity: 'the productivity in the strict sense' and the 'global productivity' - the two measures are calculated comparatively to a big corpus. The global productivity, noted P*, expresses the probability of appearance of a new word in a given morphological process (Hay & Baayen, 2002).[1] The method more used in the present research on the morphological productivity is a statistical measure in the strict sense (Baayen & Lieber, 1991; Baayen, 1992).The productivity in the strict sense, noted as *P*, represents a quantitative measure that is based on the notion of hapax legomenon.

Besides a traditional quantitative analysis of the morphological productivity, another approach to the measure of productivity was recently rediscovered in the linguistic environments – the correlation between the morphological productivity and the size of the morphological family. Prado *et al.* (2005:496) show that the size of the morphological family is strongly correlated to the word frequency: if a word is frequent, the size of its morphological family tends to be bigger. The *categorial family size* is a measure showing how the entire morphological category contributes to morphological connectivity in the mental lexical process.

While analyzing the correlation between the productivity of the affixes and the size of its morphological family in English, Baayen and Hay (2002) show that the increase of the

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[1] Baayen represents in his first works (1989, 1991) the global productivity as a possibility to incorporate the profitability of the studied process in the measure of the productivity (two process A and B can have the same P value while the one forms ten times more words than the other).

categorial family size causes growth of its morphological productivity. They define the categorial family size of the morphological family as following: « …*the 'categorial family size' of a morphological category be the sum of the (logarithms of the) family sizes of the base words of the members of this category*" (Baayen & Hay, 2002:1). For example, the categorial family size of the affix *un-* in the words *unbound, unsafe, unbrave, unwise* is a sum *log (F1) + log (F 2) + log (F 3) + log (F4)* etc. where F1, F2, F3 represents the family size of the word-bases *bound, safe, brave, wise*, etc.

The measure of the morphological productivity, very little explored for compound words, raises an important question*: Is there evidence of a correlation between the productivity and size of the morphological family of the compounds?*

The aim of this paper is to verify the potential correlation between the productivity of French compounds and the categorial family size of their morphological families. Our hypothesis is the following one: There is a positive correlation between the productivity and size of the morphological family of the compounds *garde-x* and N-de-N: the growth of the categorial size of its morphological family increases the productivity level of compounds.

Using Bayeen's (1991, 1992) productivity measure *P* in the strict sense and the model of the categorial family size (Baayen & Hay, 2002), this paper examines the productivity of the French compound nouns and explores the potential correlation between the morphological productivity and categorial size of its morphological family.

The research is based on French corpus *Frantext* through the analysis of 60 compounds *garde-x* and 49 compounds N-de-N.

Following the introduction, section 2 presents the methods of morphological productivity measurement used in present research. The corpus and analysed data are described in section 3. Section 4 discusses the results of research on the productivity of French compounds *garde-x* and N-de-N and the possible correlation between the productivity and categorial family size. Sections 5 and 6 outline major discussion and conclusions.

2. Methods of productivity measurement

In our study, two measures were used to evaluate the productivity of French compounds *garde-x* and N-de-N: the measure *P* based on the notion of hapax legomenon (Baayen & Lieber 1991: 809; Baayen 1992: 115-16; Hay & Baayen 2003: 101) and the measure of the categorial family size (Baayen & Hay : 2002). Evaluation of productivity based on the hapaxes considers the productivity of the morphological process inside the same corpus (Frantex) and it is calculated using the following formula:

(1) $P = n_1 / N$

where P= productivity; n_1 = the number of hapax legomenon (the forms that appear only once in a big corpus); N = the total token frequency of words created in the corpus. This calculation evaluates the type productivity of compounds as a whole structure while showing the rate of growth of the vocabulary.

According to this measure of productivity, a category with a big number of words of high frequency will have a big value of N and, consequently, a lower degree of productivity. This calculation evaluates the type productivity of compound nouns as a fixed (whole) structure while showing the rate of growth of the vocabulary. In order for the hapaxes to represent true neologisms, it is necessary that the research of the *P* is done on a very big corpus (tens of millions of words).

The second measure implied in the evaluation of the morphological productivity of compounds *garde-x* and N-de-N is the measure based on the categorial family size of the morphological family proposed by Baayen and Hay (2002). In their work on the productivity of the English affixes and the bases of derived words, Baayen and Hay (2002:1) show that there is a strong correlation between the degree of productivity of the base and the size of the morphological family. Words such as *man* or *coin* are presented as constituents (bases) in several complex words; they possess a high degree of productivity and their morphological families are quite big. This effect, linked to the size of the morphological family, was also observed in Dutch, German, English, Hebrew and Finnish.

The measure of the categorial family size of the morphological family proposed by Baayen and Hay (2002) is calculated in two steps.

a) First, the size of the morphological family of the analysed form is measured (for example, the family of the word *chou-fleur*, includes all the derived and compound words formed from this base, except the bases themselves: *chouchou, chouchouter, chou-blanc, fleurir, fleurette, fleuriste, fleuron*, etc). According to the definition of Schreuder and Baayen (1997: 118), the morphological family includes all the words that are formed with the bases word through derivation or composition.

b) Secondly, to measure a categorial family size of a morphological family, a logarithmic formula representing the sum of the (logarithms of the) family sizes of the base words of the members of this category is applied:

(2)   log (F1) + log (F 2) + log (F 3) etc.

where F1, F2, F3, etc. are the sizes of the morphological family of the base words[2]. The measure of the categorial family size calculates the frequency of the constituent of the compounds as well as the frequency of the members of their morphological families.

3. Corpus and material preparation

Since the measure of morphological productivity based on hapax legomenon requires that forms are extracted from a large corporus, two sources were used to create a primary database of French compound nouns. The Gallica corpus of French National Library (50 million words) was employed to develop a list of 60 compounds *garde-x*.

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[2] Following Schreuder et Baayen (1997), Moscoso del Prado et al. also suggest that the effect of the size of the family is logarithmic by the nature: "Like the word-frequency effect, the family-size effect is logarithmic in nature. Robust effects are typically observed in the range of 0–40 family members, after which there is generally a floor effect". (Moscoso del Prado et al. 2004 :1272)

Littré's *Dictionnaire de la langue française* (1863-1877) with 80,000 entries was used to create a list of 49 compounds N-de-N. Gallica corpus of the National Library of France offers 1200 volumes in mode text that represent various domains such as history, literature, science, philosophy, law, economics and political science. This corpus reflects a general portrait of the French language usage from 16th to 21st centuries. Littré's *Dictionnaire* is a normative dictionary that reflects a state of the classical French language and its good literary usage between the 17th and the 19th centuries; this dictionary remains an important stage in the development of the French language.

The larger corpus Frantext[3] was later used to validate the frequency of each token and type of the words being analysed. Frantext database consists of up to 4000 texts (more than 150 million words) covering several domains such as science, arts, literature, technology, politics, philosophy, etc. This corpus has a sufficient size to apply a series of quantitative measures and analyse necessary statistics such as token number, hapaxes, frequency of family members, etc.

The corpus is divided in four periods according to their importance in the history of the French language: 1606-1694 (17.3 million words); 1695-1798 (34.4 million words); 1799-1872 (41 million words); 1873-1920 (28 million words). The hapaxes that appear in Frantext are good markers of the productivity of the studied process (in other terms, their aptitude to form new words): the bigger is the number of hapaxes, the more productive is a studied morphological process. This is the reason why the size of corpus is extremely important: a too limited corpus risks misrepresenting the unique forms such as neologisms.

The *garde-x* compounds analysed in the current research are distributed over the following types:

(3)   a. N-N : garde-temps, garde-sel, garde-notes

       b. V-N : garde-main, garde-cote, garde-feu

       c. N-Prép-N: garde de santé, garde de chasse

       d. N-A : garde-fou

N-de-N compounds represent the following types:

(4)   a. bec-de-N : bec-de-lézard , bec-de-cigogne, bec-de-cane, etc.

       b. belle-N : belle-de-jour, belle-de-nuit, etc.

       c. cul-de-N: cul-de-jatte, cul-de-poule, cul-de-sac, etc.

       d. coup-de-N : cou-de-pied, coup de poing, etc.

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[3] The Frantext database (http://humanities.uchicago.edu/orgs/ARTFL/ (formerly the *Trésor de la Langue Française*) was elaborated in 1960. It included less than thousand works from 19th and 20th centuries selected from the bibliographies of the history of literature. This corpus quickly became enriched towards 1970 with scientific and technical texts. Afterward, the funds spread in a manner to cover the three preceding centuries as well as the following period. The corpus continues to grow progressively.

Table 1 gives a general overview of the statistics representing the total token frequency of compounds *garde-x* and N-de-N in Frantext from 1606 to 1920:

TABLE 1: Token frequency of compounds N-de-N and garde-x in Frantext corpus

	1606-1694	1695-1798	1799-1872	1873-1920	Total
N-de-N	113	173	204	277	767
garde-x	118	320	502	147	1087
works	141	183	283	64	671
words	4,884,725	12,524,257	20,608,307	5,208,641	43,225,930

The results included in Table 1 show that N-de-N compounds were used more frequently during the third and fourth periods (204 and 277 occurrences respectively); *garde-x* compounds demonstrated a higher frequency during the second and third studied periods (320 and 502 respectively).

4. Results

4.1 Morphological productivity of garde-x compounds During research, 25 hapaxes related to compounds *garde-x* were observed. While applying the measure based on hapaxes of Baayen (Baayen & Lieber, 1991; Baayen, 1992), the morphological productivity of the compound nouns *garde-x* was calculated as follows:

$$(5) \quad P = \frac{25}{1316} = 0.019$$

where 25 is the number of forms *garde-x* formed by the compounding process and occurring in Frantext only once; 1316 is the total token frequency of compounds *garde-x*.

The changes in the rate of the morphological productivity of the compounds *garde-x* showed the following results summarized in Table 2:

TABLE 2: Productivity of compounds *garde-x* in Frantext corpus

Période	n_1	N	P
1606-1694	2	75	0.027
1695-1798	8	430	0.019
1799-1872	2	491	0.004
1873-1920	13	320	0.041
Total :	25	1316	0.127

where n_1 is the number of forms *garde-x* formed by the compounding process and occurring in Frantext only once; N is the total token frequency of compounds *garde-x*; P is the morphological productivity of compounds *garde-x*.

Table 2 shows that the morphological productivity of the compounds *garde-x* was elevated during the fourth and the first periods ((P=0.041 and P=0.027 respectively). The rather high level of productivity of this type of compounds during the first period could be explained by loss of importance of Latin and the introduction of French language into daily life through several neologisms. The morphological productivity of compounds *garde-x* significantly lowered during the years 1799-1872 (P=0.004).

4.2 Productivity and categorial family size of compounds garde-x

According to the definition of Schreuder et Baayen (1997: 118), the morphological family includes all the words that are formed with the word base through derivation or compounding, while excluding the base itself.

To measure the categorical family size of the compounds *garde-x*, we followed the two steps mentioned above:

1) First, the size of the morphological family of every compound was calculated for each of the four periods. To measure the size of the morphological family of compounds *garde-x*, we released all the words belonging to the same morphological family of each of *garde-x* form constituent. For example, for the compound *garde-chasse*, we were looking in Frantext for the words such as *garder, gardeur, gardeuse, gardien, gardienne,* etc. (garde) and *chasser, chasseur, chasseresse,* etc. (chasse).

The distribution of the morphological family members of the compounds *garde-x* by period is presented in Table 3:

TABLE 3: Morphological family size of compounds *garde-x* in Frantext corpus

garde-x	1606-1694	1695-1798	1799-1872	1873-1920
types of compound	9	20	27	16
size of morphological family (total)	46	134	231	200
size of morphological family (average)	5.1	6.7	8.6	12.5

While analyzing the data in Table 3, we noticed a significant growth in the average number of the size of morphological members for four studied periods: from 5,1 members fin the first period to 12,5 members in the fourth period.

2) Secondly, the logarithmic formula was applied to calculate the categorical family size of the compounds *garde-x*. For example, the categorical family size of this type of compound for the first period was measured as follows:

(6) $\log(6) + \log(8) + \log(5) + \log(4) + $ etc. $= 6.23$

where $\log(6), \log(8), \log(5), \log(4)$, etc. are the logarithms of the family sizes of the base words.

The correlation between the level of productivity and the categorical family size of compounds *garde-x* is captured in the Table 4:

TABLE 4:Morphological productivity and family size of compounds *garde-x* in Frantext corpus

Mesure	1606-1694	1695-1798	1799-1872	1873-1920	average
N	75	430	491	320	329
F	46	134	231	200	152.75
T	6.23	16.43	24.87	15.80	15.8
P	0.027	0.019	0.004	0.041	0.023

where N is the total token frequency of compounds *garde-x*; F is the size of the morphological family; T is categorical family size of the morphological family; and P is the morphological productivity of compounds *garde-x*.

The analysis of the data in the Table 4 shows that in the case of compounds *garde-x*, there is a negative correlation between the morphological productivity and the specific category size of the morphological family. The compounds related to the third period (1799-1872) possessing the highest categorical family size (T=24.87) have the lowest level of productivity (P=0.004). The compounds with the smallest categorical family size ((T=6.23) possess a higher level of productivity (P=0.027).

4.3 Morphological productivity of N-de-N compounds

According to the measure based on the number of words of the given category that occur only once in the corpus (Baayen & Lieber, 1991; Baayen,1992), 23 hapaxes were discovered for compounds N-de-N in Frantex corpus (all periods combined). The morphological productivity of the compound N-de-N was calculated as follows:

$$(7) \quad P = \frac{23}{767} = 0.030$$

The productivity of compounds N-de-N differs across different studied periods. The results of our research are summarized in Table 5.

TABLE 5: Productivity of compounds *N-de-N* in Frantext corpus

Période	n_1	N	P
1606-1694	5	113	0.044
1695-1798	3	173	0.017
1799-1872	6	204	0.029
1873-1920	9	277	0.032
Total :	23	767	0.122

The analysis of Table 5 permits to conclude the following:

1. The compound N-de-N were more productive during the period from 1606 to 1694 (P=0.044).

2. The level of the morphological productivity of compounds N-de-N was 2.5 times lower (P=0.017) during the years 1695-1798 in comparison with the first period.

4.4. Productivity and categorial family size of compounds N-de-N

The categorical family size of the compounds N-de-N was calculated following the same two steps mentioned above for compounds *garde-x*.

1) First, the size of the morphological family of compound N-de-N was determined for each of the four periods as F1=63; F2=70; F3=90 and F4=102 respectively.

2) Secondly, the logarithmic formula was applied. For example, for the first period (1606-1694), the categorical family size of compounds N-de-N with 12 different types was measured as follows:

(8) log(4)+log(3)+log(6)+log(6)…..=8.17

The correlation between the rate of productivity and the categorical family size of the compounds N-de-N is outlined in Table 6.

TABLE 6: Morphological productivity and family size of compounds N-de-N in Frantext corpus

mesure	1606-1694	1695-1798	1799-1872	1873-1920	average
N	113	173	204	277	192
F	63	70	90	102	81
T	8.17	8.42	11.66	13.56	10.45
P	0.044	0.017	0.029	0.032	0.031

where N is the total token frequency of compounds N-de-N; F is the size of the morphological family; T is categorical size of the morphological family; P is the morphological productivity of compounds N-de-N.

Table 6 represents the vocabulary growth for compounds N-de-N throughout four studied periods. Our results can be summarized as follows. First, we have seen a negative correlation between the productivity and the categorical family size of compounds N-de-N through two studied periods (P1=0.044; P3= 0.029 vs T1=8.17; T2=8.42 respectively). Secondly and conversely, instead of lower productivity level for bigger categorical family size as for *garde-x* compounds, we observe the positive correlation between the morphological productivity and family size of compounds N-de-N for the third (1799-1872) and fourth period (1873-1920): P3=0.29; P4=0.032 vs T3=11.66; T4=13.56 respectively.

5. Discussion

The study conducted on the compound nouns *garde-x* and N-de-N evaluated the quantitative productivity of these forms using two different statistical measures: the

measure based on the hapaxes ((Baayen & Lieber, 1991; Baayen,1992; Hay & Baayen, 2003) and the measure of the family size of the morphological category ((Baayen & Hay, 2002).

This study showed that compounds *garde-x* and N-de-N can be considered productive in the analyzed corpus: the average productivity of compounds *garde-x* through four analyzed periods is P=0.023; the compounds N-de-N demonstrate an average productivity during the same periods as P=0.031.

The aim of this study was to verify the possible correlation between two measures of productivity for compounds *garde-x* and N-de-N. We advanced the hypothesis that there is a positive correlation between the productivity and size of the morphological family of the compounds *garde-x* and N-de-N: the growth of the categorial size of its morphological family would increase their level of productivity (following the discovery of positive correlation between the productivity of the affixes and the size of its morphological family in English by Baayen and Hay (2002)).

The results presented in the Table 4 and 6 show that, globally, in the matter of compounds *garde-x* and N-de-N, there is a negative correlation between the productivity and the categorial size of their morphological families. For *garde-x* compounds, this correlation is evident for the first (1606-1694), second (1695-1798) and third period (1799-1872) where the growth of the family size of a morphological category (T1=6.23; T2=16.43; T3=24.87) diminishes the level of productivity of this type of compounds (P1=0.027; P2=0.019; P3=0.004). For N-de-N compounds, this correlation stays negative for the first and second period (T1=8.17; T2=8.42 vs P1= 0.044 and P2= 0.017 respectively).

It is interesting to note that the negative correlation between morphological productivity and categorial family size does not hold for compounds *garde-x* during the fourth period (T4=15.80 vs P4=0.41). The data shows that the highest level of productivity is related to a medium categorial family size of the morphological family for this type of compounds. In the matter of compounds N-de-N, this correlation was positive for the third and fourth analysed periods (T3=11.66 vs P3=0.029 and T4=13.56 vs P4=0.032). At the same time, the highest level of productivity of compounds N-de-N is correlated to the smallest categorial size of their morphological family (T1=8.17 vs p1=0.044).

6. Conclusion

In contrast to the discovery of a positive correlation between the productivity of the affixes and the size of their morphological family in English (presented by Baayen and Hay (2002)), the results of the study of the compound nouns *garde-x* and N-de-N show that this correlation does not always hold for French compounds. Generally, the growth in the categorial size of the morphological family of the compound *garde-x* and N-de-N decrease the level of their morphological productivity.

The negative correlation between the level of productivity and the size of the morphological family for the compounds *garde-x* and N-de-N during the first (1606-1694) and the second periods (1695-1798) can be explained by the specific linguistic situation in France at that period of time. The fact that the Latin was less frequent and began losing its importance at this time allowed the French language to form new words and be widely introduced into daily life through several neologisms.

Our findings suggest that more research on different type of French compounds and their morphological families is necessary.

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